TIME-LIMIT VS. WORK-LIMIT IN LEARNING

BY

EVELYN W. BETTS

A DISSERTATION

SUBMITTED TO THE BOARD OF UNIVERSITY STUDIES OF THE JOHNS HOPKINS UNIVERSITY IN CONFORMITY WITH THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Reprinted from MENTAL MEASUREMENT MONOGRAPHS

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I. Introduction

Wise and unwise application of mental tests has aroused much discussion wherein need of carefully investigating many factors in such tests has been shown. The time factor is a very important one. Does imposing apparently arbitrary time limits penalize the slow, cautious, sure individual of popular notion? That consideration of this question has led to varying attitudes is indicated by even a few notations from the literature on mental tests. Necessity for securing and interpreting both rate and accuracy scores is an ever-present problem in any type of test according to Courtis (5) and Gates (13). Ballard (1) warns that ignoring the time limit nullifies certain tests. Caution lest the time limit be given too great prominence is suggested in greater emphasis on individual testing, in efforts to provide a work-limit device for group tests, in advocacy of a group power test with generous or no time limits rather than a speed test. Many experimenters, maintaining that to do things well and quickly is characteristic of the higher intelligence, demand recognition and evaluation of both speed and

power. In this group are Freeman (8), Jones (16), Kelley (17), McCall (16), and Thorndike (26).

II. A Brief Résumé of Certain Experiments Dealing with the Effect of Time Limits on the Quality and Quantity of Work

Recognition of the importance of a time or speed factor in mental measurements has long been a characteristic of scientific psychology. Emphasis upon reaction time as an indicator of individual differences in the psychological laboratory naturally led to emphasis upon quickness of response as an indicator of mental alertness in tests applied outside the laboratory. Psychologists' regard for this time factor is shown in the rigid adherence of most group tests to a fixed time limit. Although, during the early years of the twentieth century, doubt was cast upon the validity of quickness of response as a measure of intelligence, about 1916 reaction against the group test with definite time limit raised the following questions. (1) Is there a speed ability separate and distinct from general intelligence? More concretely, is there that slow but sure individual of popular notion who possesses intelligence of high degree, and can, if granted but sufficient time, outstrip a speedier but less intelligent rival? (2) Is this speed ability relatively constant for all types of performance? Is the quick individual always quick, or is his speed of reaction a function of the type of performance tested? (3) Is measurement of rate of response or rate of acquisition adequate measurement of general intelligence? Is the best test of intellectual ability a speed test with time limits, a power test with time limits, or a power test with ample or unlimited time? (4) How should rate of response be measured? Should score be based upon relative amounts of time required for reactors to complete an assigned task, or upon relative amounts of work accomplished on the assigned task during a fixed period of time? Is either method equally reliable? Since it is with the last question that the present experiment is concerned, only investigations which seem to throw light upon it will be considered.

One rather early study of effects of limited and unlimited time upon efficiency in learning is that of Myers (20). Thirteen girls

of a psychological laboratory class studied four lists of words. Each list began with a number and contained five words. The girls were required to know the words and to be able to locate each under its proper number. They were directed to work as quickly as possible for accurate recall. The shortest time taken was eight minutes, forty-seven seconds; the longest, twenty-two minutes, forty seconds; the average time, fourteen minutes, forty-seven seconds with an average deviation from the average of four minutes, twenty-eight seconds. In the recall test nine made perfect records. The same task was given a second group, twenty-four girls inferior in scholastic ability to the first group. Now the time for study was limited to nine minutes—approximately the shortest study time in the first group. In the recall test ten made perfect records with five minutes less study time than the average time required by the nine in the superior group making perfect records. Furthermore, the imperfect records of the inferior group were no worse than those of the first group. As the author himself notes, although these results are not conclusive, the number of subjects being so small, they suggest consideration in education of the "piece-work" ideal of the business world.

In 1921 Mudge (19) sought to verify the opinion of a normal school class that the time limits of the Otis and the Thurstone group tests handicapped slow and accurate students. A series of nine group tests—mainly accuracy tests in a variety of tasks involving reasoning, observation, memory, and other mental functions—was devised and administered without time limits. Relative ranks in each test were compared. From obtained results the author concludes persons relatively inefficient in the timed intelligence tests used may do relatively efficient and accurate work if allowed to work more slowly.

To meet the objection—that timed intelligence tests are unjust to those individuals, who, although entirely adequate to the kind of performance demanded, combine slowness with accuracy—May and Terman (18) carried out the elaborate study of Army Alpha and Beta. Both tests were given with double time to discover the extent of improvement thereby gained. Two methods were used. By the first method, beginning with test 2 of Alpha, the men at

"single time" drew a line across the page to mark the point reached and continued, changing nothing above that line, until the double period had been completed; likewise with each test. By the second method, the entire examination was completed in prescribed fashion; then the men went back to test 2, indicated by a line the amount accomplished during the first period, and, without changing anything above that line, continued through test 2 during a period of time equal to that allowed in the first trial. From test 2 they went through the examination a second time. The Beta examination was likewise given with double time. The effect of doubling the time was studied by finding correlation between single-time and double-time scores for separate tests and for totals; correlation between single-time scores and officers' ratings of intelligence, and double-time scores and officers' ratings of intelligence; the percent of individuals gaining in the second half of the double period. Results drawn from the entire study led the experimenters to conclude that an extension of time limits would neither have improved the test nor given opportunity to many individuals to change their ratings; and further, that although a few individuals might profit by increased time, extension of time would decrease rather than increase the value of the scale as a whole.

The army experiment of May and Terman suggested Ruch and Koerth's (25) investigation. In this study Form 7 of Army Alpha was given to 122 freshmen of the State University of Iowa; of these, 70 ranked in the lowest decile, 52 in the highest of a distribution based upon the combined scores of four intelligence tests. The examination was given in three periods. In the first, the strict procedure of the Examiner's Manual was followed that results might be compared with the norms for Army Alpha; writing was with black-leaded pencils collected at the end of the period. In the second, the subjects again went through the entire test with the same prescribed time limits; now they used blue-leaded pencils for corrections and additions. Erasures of the black-leaded responses were forbidden so the examiner could compute scores for single and for double time and locate errors. After the second period the blue-leaded pencils were collected. During a short intermission the booklets of all subjects who had apparently worked themselves

out were taken. In the third period those remaining were allowed time to complete the examination; red-leaded pencils were used. Upon each booklet working time for the third period was recorded. The slowest subject required for the entire examination two hours and fifty minutes—approximately four and one-half times the regular time limit. The authors conclude from obtained correlations that dull subjects are not enabled by increased time allowance to equal the scores of the more intelligent subjects. With unlimited time, the mean of the low group is still below that of the high group with single time.

A similar investigation was extended by Ruch (24) to the Terman Group Test of Intelligence and the Reading and the Arithmetic Tests of the Stanford Achievement Examination. The Terman Group Test was given to seventh and eighth grade pupils of three Iowa schools. The pupils took the test first under standard conditions, using black-leaded pencils. When the time-limit was up, the black-leaded pencils were collected and red-leaded ones substituted, with which pupils were encouraged to work as long as they desired. Since no erasures of the black-leaded responses were permitted, and additions and corrections were made in red, gain in score due to extended time could be calculated. Comparison of single-time scores with double-time scores gave high correlation, and variability as measured by the Pearson coefficient of variability appeared to decrease. The Achievement Tests were given to sixth, seventh, and eighth grade pupils of another Iowa school. The two-period scheme of limited-time followed by unlimited-time was again observed. Black-leaded pencils and colored-leaded pencils were again used. Although the time-limit of forty minutes on each of these tests permits about ninety percent of all subjects to finish them in the allotted time, the pupils were encouraged to work themselves out before giving up their papers. Very few worked longer than double time; many failed to gain a single point by the additional time. The author, believing that correlations for single vs. unlimited time are probably as near unity as the reliabilities of the tests permit, concludes that in such tests pupils' ratings are not seriously influenced by the speed factor.

In 1923 Freeman (7), discussing the relationship between speed

and quality of work, described two experiments in which required time is compared with excellence of accomplishment. In the first experiment the Burt Reasoning Tests were given with practically unlimited time to a group of high school students. Each student's time was noted. The correlation of zero between the time taken and the score—which was regarded as entirely independent of the speed of performance—seemed to indicate little or no relation between speed and quality of work. In the second experiment students from a class in mental tests were given two standardized tests upon the content of the course; one was a multiple-answer, the other a completion test. Speed of performance was determined by the order in which papers were handed in. Correlation between the order of finishing in the two tests was $.50 \pm .05$; between the scores $.55 \pm .047$; but the correlations between the order of finishing and score gave $-.13 \pm .07$ and $-.12 \pm .07$. Freeman notes that, although high ability may produce high quality of performance and also favorably influence speed of performance, another hypothesis may be brought forth: that individuals may vary in the rate of working or in the rate of activity in general, such variation being relatively independent of the quality of work. He further calls attention to the fact that more or less accidental differences in ways of working and the character of the test itself may largely determine the relation between speed and quality. A test uniformly easy would tend to give higher correlation between speed and quality than a test of such wide range of difficulty that, although it permits the least able to score, it challenges the very ablest.

Chapman (3) in 1924 reported a word-building test given twice to pupils of the upper sections of an eighth grade. The test, taken from Whipple's Manual, requires the subject to make from six letters as many different words as he can. The first trial varied from Whipple's procedure only in requiring the pupils to write after each word the time which was shown on large cards at five-seconds intervals throughout the test. Three factors—success, speed of thought, and persistence—were investigated. Success was measured by the total number of words obtained; speed of thought by the average time per word; persistence by the time con-

sumed before the task was given up. Results gave a correlation of .65 between persistence and success, of −.29 between speed of thought and persistence, and of .28 between speed of thought and success. In the second trial the test was repeated with a fifteen-minute time limit. With persistence time thus maintained the same for all pupils, the correlation between speed of thought and success rises from .28 to .63. These results led Chapman to point out that, speaking in terms of statistical averages, the extent to which the brighter pupil excels the duller pupil is disappointing. The persistence of the slow group goes a long way towards compensating for their lack of speed.

In 1924 Bernstein (2) at the University of London recorded an enquiry concerning the possible existence of a speed factor which operates independently of general ability. He employed five kinds of tests—Sentence Completion, Directions, Concomitants, Analogies, and Moral Classifications; each test was of two types. The first type, in which ample time was allowed, he terms "leisure" tests; the second, in which time allowed was too brief for any but the fastest, "haste" tests. He assumed that slower subjects could be expected to do relatively better in the "leisure" tests. Results, however, gave no indication that subjects really do better in the "leisure" tests than in the "haste" tests. In one group tested the average intercorrelation between "leisure" tests is .69, between "haste" tests .67, between "leisure" and "haste" tests .66; in a second, corresponding correlations are .71, .69, and .73. The two types of tests thus correlate with one another to the same extent as the members of either set intercorrelate among themselves.

Clark (4), accepting Thorndike's hypothesis that score in an intelligence test is determined by the individual's speed of reaction, range of information, general power or level, sought to discover the amount of association between each of these qualities and scores earned by a group of seventh and twelfth grade pupils in three commonly used tests. One of these, the Stanford Revision, is practically without time limit: the others, the Otis and the Terman Group Tests, have definite time allowances. Speed was determined by the rate at which pupils solved arithmetic problems and completed sentences of the I. E. R. tests. Each pupil was

tested individually, and a stop-watch record of the time for each item recorded. Level or power was measured likewise by solving arithmetical problems and completing sentences. Here the I. E. R. Arithmetical Problem Tests and the I. E. R. Completion Tests were given as group tests with the time allowance needed to complete the test series. The measure of level was that level on which and up to which the pupils did correctly fifty per cent of the elements. The I. E. R. Information Tests supplied a measure of information. Speed as measured here has the lowest correlations with intelligence test scores. From the evidence of his correlations, the author concludes that level in general or range in general is more closely associated with intelligence test scores than is speed in general.

To investigate the degree of relationship between the speed of response in intelligence test material and the quality of the answers given was the purpose of Highsmith's (14) study reported in 1925. Three sets of measures were used. The Stanford-Binet served as the criterion of intelligence inasmuch as this test in no way emphasizes speed of response. The National Intelligence Test was employed as a time group mental ability test. Rate tests, both linguistic and non-linguistic, of material similar to that found in group intelligence tests but presenting a minimum of difficulty, were utilized to measure speed of response. The subjects were boys and girls of the fifth, sixth, and seventh grades. Correlations were found and results analyzed: first, to discover how important in the measurement of intelligence was the rate of response factor; second, to find the relation between rates based on material of different degrees of difficulty and intelligence. Highsmith concludes that rate of response to test material is an unsatisfactory measure of intelligence; that the N. I. Test measures the rate of response better than it measures intelligence; that the N. I. Test measures intelligence but little better than the simple linguistic rate tests used; and that the length of the test is more important in measuring rate in non-linguistic material. He warns against employing a composite of group tests to evaluate a new group test lest thereby the importance of the rate element in the group test be over-emphasized.

Hunsicker (15) in 1925 reported a study very similar in purpose, since it aimed to investigate the relation between rate and level as they appeared in arithmetical ability in the I. E. R. Arithmetical Problems and sentence completion ability in the I. E. R. Completions. The first two sheets of these tests, since they offered a minimum-difficulty or no-difficulty level, were utilized as rate tests; the following sheets, which increase in difficulty, as power or level tests. The subjects were school children and college students. Since group testing proved too unreliable, individual testing was used throughout. Rate was measured in time consumed in the accomplishment of the rate tests; power or ability, by the highest level in which and up to which fifty per cent of the elements were correctly done. Correlations between rate and level in arithmetic and also between the same two factors in completion ranging from .39 to .61 are considered indication of consistent and fairly positive relationship between rate and ability; correlations from .57 to .81 between rate in arithmetic and rate in completion, an indication of characteristic individual differences in rate of work; correlations from .55 to .71 between level in arithmetic and level in completion, an indication that the capable individual tends to be generally capable. The general conclusion is, although these positive correlations give evidence of the constancy of the relationship between rate and ability, they do not warrant dependable prediction of one trait from the amount of the other.

Dowd (6) recorded in 1926 an investigation to determine the consistency of rate of work for different types of work. An unselected group of sixth-grade Cincinnati school children served as subjects. To measure rate of work five types of tests—Cancellation, Speed of Movement, Writing, Reading, and Arithmetic—were given as group tests with definite time limits. The simplicity of these tests made their degree of difficulty approximately constant. Reliability for all was above .90. The Otis Advanced Examination was given as an example of a widely used intelligence test. Comparison of rate measures yielded correlations from .136 to .870 with the larger number of coefficients at the lower end of the range. High correlations are between tests of similar content. These speed measures showed such little agreement that the author

believes it ridiculous to consider coefficients—generally low—between these rate tests and the intelligence test any indication of the true relation between rate of work and intelligence. She concludes that, since low correlations cannot be due to low reliability, they tend to disprove the hypothesis that a person is generally speedy.

In 1926 Freeman (8) reported an experiment to test the effect of double time on a power test and a speed test. Both tests, given to a university class, were composed of number completion examples: one was predominately a speed test; the other, predominately a power test. Correlations between single-time and double-time for the speed test give $.87 \pm .03$; for the power test $.78 \pm .04$; and between speed single-time and power single-time $.63 \pm .06$. Freeman concludes that evidence of a distinction between speed and power appears in the comparative lowness of the correlation between the speed and power tests; and the lower correlation between single and double-time in the power test (when compared with the correlation of the speed test) suggests that ample time should be allowed for a power test.

In 1926 Peak and Boring (23) published an investigation in which they sought to locate the time loss of the slow but sure individual. They took the viewpoint that the intelligent reaction comprises the solution of a problem against time, a better solution being a more rapid one. To discover whether the slower subject tends to do every item of a timed intelligence test more slowly, four typical tests—Army Alpha, Forms 5 and 6, and the Otis Self-Administering Tests, Forms A and B—were given to five advanced students in psychology. While their instructions—to work as quickly and as accurately as possible since both time and accuracy would count—tended to produce the usual attitude of a subject in a time-limit intelligence test, the tests were completed: time in seconds for each item was recorded by a stop-watch. Seldom did a subject require more than three times the standard time to finish. With accuracy kept constant by selection of only those items to which all subjects responded correctly, significant individual differences in the rate of response appeared; difference in speed was localized in the item. When reaction time to a visual stimulus in the labo-

ratory gave a correlation of .70 with the time of the test items of the Alpha Test, and of .90 with those of the Otis Test, the authors concluded that probably the most important factor in individual differences in the intelligent act is the speed of reaction. High correlation occurs between score in an intelligence test, speed in an intelligence test, and speed in a simple reaction; such correlation is destroyed by great lengthening of the time-limits for a standard test because the faster subjects cannot utilize the additional time.

To test the assumption that certain people, because of slow reaction, are placed at a decided disadvantage in a fairly rigorously timed intelligence or achievement test was the purpose of a study by Walters (27). He sought especially to discover what effect an extension of time in such test would have on the resulting score. A group of sixth and seventh grade school children served as subjects. Five tests were given under conditions of half-time, standard-time, and extended-time. These tests were the N. I. Test, Scale A, Form I; Mentimeters by Stockbridge and Trabue; the Otis Group Intelligence Scale, Advanced Examination, Form A; the Indiana University Mental Survey Scales; Cross-Out Tests, Schedule E; the Pintner Non-Language Mental Tests. To compare the time effect on these tests two criteria were used. The first was mental age as determined by the Stanford Revision. The second was a "Composite Criterion" composed of these three factors: (1) the "School Criterion" or the school's estimate as shown by (a) teachers' rankings, (b) school grades, and (c) school progress, or rate of advancement from grade to grade; (2) the "Educational Criterion," scores from a number of educational tests; (3) the Stanford Revision Mental Age. Influence of rate of reading was measured by correlating scores earned on rate of reading tests with the Stanford Revision Mental Age, with the "Composite Criterion," and with the scores of the several group tests under conditions of half-time, standard-time, and extended-time. Two methods were employed for measuring the contributions of speed and of power. In the first, a specially devised rate-of-work measure was correlated with the intelligence test scores for each of the three time periods. In the second, the coefficient of alienation was applied to the correlation between standard-time and extended-time scores:

extended-time scores were assumed to be pure power scores, and lack of correspondence between them and standard-time scores due to the speed factor. The speed or rate-of-work measure was a composite of: (1) a group of tests more or less generally recognized as speed tests; (2) the amount attempted under conditions of half-time on nine tests selected from the National and the Otis booklets; (3) the extra time needed on the five intelligence tests during the unlimited-time period. To measure the extent to which pupils profited by extended-time, the total group of subjects was divided, on the basis of the amount attempted under standard-time, into a slower and a faster half, approximately equal as to chronological age, Stanford Revision Mental Age, and Stanford Revision Intelligence Quotient, and gains were computed for the two halves separately. This was done for the National, the Otis, and the Mentimeters Tests. In analyzing the effects of the time allowances, correlations were computed between scores earned under the different times; between these scores and the two criteria selected; between the gain in score due to extended-time and (1) the amount of added time expressed in half-minute intervals, (2) the Stanford Revision Mental Age, and (3) the Stanford Revision I.Q. From his results Walters concludes that although extension of time has little effect upon the predictive value of these five tests, standard-time scores tend to emphasize the rate at which pupils work on the tests, while extended-time scores tend to emphasize the degree of difficulty they can attain. Consequently, the use of standard-time or extended-time scores in the classification of pupils rests upon the question of the relative importance of speed and power. In regard to the relationship between rate and power factors of intelligence in general Walters concludes: that correlations between rate measures—all above .40—point to actual correspondence between rate in one complex function, or combination of functions, and rate in another; that his rate measures, with the possible exception of Total Rate of Reading Composite, do not warrant belief that the rate aspect of performance can be utilized for the prediction of general intelligence; that a considerable portion of the pupils were slower than others in their rate of performance but were not duller.

The hypothesis that high correlation between single-time and double-time scores of an intelligence test marks the test as a speed test is challenged by Freeman (9). He points out that a time allowance of such length that every one can attempt every item, eliminates the time factor and leaves the power factor alone significant. In such a situation high correlation between the scores indicates power is measured by the original time-limit test; low correlation, speed. He suggests, therefore, the proper procedure in testing is to compare scores earned with time-limit with those earned with unlimited-time; and gives the results of such an experiment. The Dearborn Group Test, Series II, Examination C, was given to sixth and seventh grade school children: first, with the set time-limit; then, several days later, with double-time. Every one had time to finish and look over his paper. The correlation of .88 $\pm$.01 between the two sets of scores and the slight increase in the scores themselves during the extended time was interpreted as evidence that this test is chiefly a measure of power. Freeman points out that a time-limit does not make a test a measure of rate, and urges complete elimination of a time-limit in studying the influence of rate and power upon test scores.

Garrison (12) made a study in which he attempted to answer several questions regarding the rate of response in various activities. Students from a class in general psychology served as subjects. Two types of test were used: speed tests and tests of general intelligence. The speed tests are classified thus: two reading tests for speed of vocal responses; card-sorting and card-distribution as a measure of sensori-motor activity in which the motor element is prominent; tallying, substitution, and cancellation as a measure of sensori-motor activity in which the sensory element plays an important part. The two intelligence tests, for rational organization and higher thought activities, were the Otis Self-Administering Test and an analogies test. With but two exceptions tests were given with time-limits and results were given in terms of work accomplished per unit of time. The exceptions were the reading tests, where the record was a stop-watch measure of speed of response, and the analogies test, where to obtain a true measure of power, the time-limit was such that all subjects could finish. Cor-

relations between the speed tests and the two tests involving higher mental processes are consistently low: the author therefore concludes that the type of performance determines the correlations between speed and higher mental ability.

In 1930 Patterson and Tinker (22) presented an experiment designed to discover whether the time-limit method and the work-limit method of administering speed tests were equally valuable. The Chapman-Cook Speed of Reading Tests—a reading test with two equivalent forms containing paragraphs of equal difficulty—were used as test material. Over 1000 students enrolled in elementary and advanced psychology served as subjects. In the time-limit test the time-limit employed was one and three-quarter minutes; in the work-limit test, the subjects recorded on their papers the time of finishing. This time, shown by a letter code placed on the blackboard, changed every ten seconds. The subjects were grouped in four divisions. Group I was given Form A by time-limit method, then Form B by work-limit; Group II, Form A by work-limit, then Form B by time-limit; Group III, took Forms A and B by work-limit; Group IV, Forms A and B by time-limit. Groups I and II correlations give the intercorrelations between the two methods of testing: Groups III and IV correlations, the reliability coefficients for the two methods. The correlation for Group I is $.87 \pm .01$; for Group II, $.84 \pm .01$; for Group III, where work-limit is compared with work-limit, $.86 \pm .02$; and for Group IV, where time-limit is compared with time-limit, $.84 \pm .01$. The true correlation between the two methods, computed by use of the attenuation correction formula, was found to be 1.00; therefore, in this experiment the two methods—time-limit method and work-limit—are equivalent. The authors concluded that the two testing methods agree with each other as nearly as either agrees with itself.

In 1931 Freeman (10) reported an experiment to determine the effect of unlimited time on scores in three widely used tests: the N. I. Test (Scale A, Form I); the Otis Advanced Examination, Form A; the Terman Group Test of Mental Ability, Form A. Each test was first administered with its regular time-limit; the N. I. Test to sixth-grade pupils, the Otis Test to eighth-grade pupils,

and the Terman Test to eleventh-grade pupils. When on the next day the test was repeated, the pupils were encouraged to work carefully, taking as much time as required. Correlations between the scores under different times were .83±.02 in the N. I. Test; .58±.06 in the Otis Test; .93±.01 in the Terman Test. The author concludes the three tests studied here, together with the Dearborn test, previously investigated, measure power chiefly and grant relatively little importance to speed. The only possible exception to this is the Otis Test. He, further, denies the conclusions of Peak and Boring emphasizing the importance of speed in determining individual differences in the intelligent act, maintaining the test scores of a small but ever-present group of individuals who are penalized by an imposed time-limit do not truly present the relative levels they are capable of attaining.

Summary. Even so brief an array of experiments gives evidence of decided disagreement. Three methods, in general, serve for investigating the effect of a time-limit on the relative test score of the individual. First, results in two different tests—one primarily a test of speed, and the other primarily a test of mental ability—are compared. Second, the same test is studied from two angles and the rate of work in it compared with the quality of performance. Third, the same test is again utilized—but now given under varying time conditions—standard, double, and unlimited—and the resulting scores for each period contrasted. From such experiments, however, proceed widely differing conclusions. At the one extreme stand experimenters maintaining that the imposition of a time-limit method undoubtedly penalizes those individuals—a small, but ever-present group—who are slower, but not duller. At the other extreme stand investigators who take the definite position that speed of reaction is perhaps the most important factor determining individual differences in the intelligent act, and consequently administering a standard test with great lengthening of time-limits penalizes the brighter and faster subjects who have no opportunity to utilize the additional time. Other investigators claim that for a speed test either method of testing—time-limit or work-limit—is satisfactory, but make no claim to settle the case of the power test. The many and varied factors

that influence test scores play so important a part in every investigation that insistence upon the superiority of either method of test procedure may go unchallenged only after most careful experimentation and most scientific analysis.

III. The Aim of the Present Study

The purpose of this investigation was to study the types of work accomplished by certain individuals under different working conditions. Each individual was given two work periods. In one period—the time-limit period—a time-limit was imposed and the individual, one of a group, knowingly worked against time. In the other—the work-limit period—the individual, tested alone, was granted unlimited time to complete the assigned task: the time required was recorded. The tasks assigned for these time-limit and work-limit periods were two forms similar in character. In the main part of the experiment a Pattern Completion Test devised especially for the investigation was used. Later the plan of time-limit and work-limit periods was continued with a second set of test forms, similar to each other, but radically different from those originally used. The achievements of the tested individual in the time-limit period and in the work-limit period were studied and compared, with the hope that some knowledge might be gleaned regarding the period more advantageous to the individual tested, and the period which gave more accurate information concerning the individual's ability in that type of test.

IV. Experimental Procedure

A. THE SUBJECTS

The subjects of the major investigation were high school students. In age they ranged from twelve to twenty; in scholastic rank, from first year to post-graduate. They form a rather highly selected group in that: they were all girls; they were college preparatory pupils; their attitude was markedly favorable since they volunteered their services. Before either time-limit or work-limit test was given, two groups, G and I, were formed on the basis of the Intelligence Quotient as determined by the Otis Higher Exami-

tion, Form A (21). These groups were assumed to be of approximately equal mental ability. In Group G the group time-limit test period preceded the individual work-limit test period. Consequently each individual of G experienced the assigned task first while working with other members of this group against a time limit; then, later, working alone, completed a similar test form—such completion being the sole requirement. Insistence upon an exact uniform time interval between the group time-limit and the individual work-limit periods was prevented by the necessity of accepting that time which each subject could offer for the individual work-limit period: in almost all cases, however, the individual work-limit period was located in the second or third day after the group time-limit test period. In Group I, the individual work-limit test period was first, the group time-limit test period second. For each individual of I, therefore, the group time-limit test came two or three days after she had accomplished a similar task, working alone and at her own speed. This plan was devised with the hope that the work of neither period would be penalized by the position of the period; and, further, that variation in time-limit and in work-limit performances might be shown not only in a new and untried task, but also after experience in a similar piece of work. During the course of the experiment Group G suffered more than Group I from certain uncontrollable disadvantages. The requirement that the conditions of the group time-limit test approximate those of an ordinary class examination restricted available reactors almost exclusively to students in the experimenter's classes. The closing of the school year prevented the completion of records by several of Group G. The eagerness of certain subjects to try the individual test gave Group I a larger proportion of keenly interested individuals. In the Pattern Completion Tests Group G includes 81, Group I 87. In the Omitted Letter Tests Group G includes 34, Group I 48. The distributions of each group in age, school year, and I.Q. as determined by the Otis Test are shown in the following Table (Table I).

Other subjects were utilized to determine the relative difficulty of time-limit and work-limit test forms. Of these the first group comprised 83 pupils—48 boys and 35 girls—from the fourth grades

TABLE I

Distributions according to age, school grade, and intelligence quotient as determined by the Otis Higher Examination, Form A, of reactors in pattern completion tests and omitted letter tests

AGE			INTELLIGENCE QUOTIENT			SCHOOL GRADE		
Years	G	I	I.Q.	G	I	YEAR	G	I
			Pattern completion tests					
12	3	1	125–130	1	3	1st	15	0
13	2	9	120–124	5	12	2nd	17	36
14	13	8	115–119	8	11	3rd	27	9
15	13	17	110–114	13	19	4th	22	41
16	22	20	105–109	13	12	P. G.	0	1
17	23	20	100–104	23	12		81	87
18	4	10	95–99	6	6			
19	1	1	90–94	9	7			
20	0	1	85–89	1	2			
	81	87	80–84	1	1			
			75–79	1	2			
				81	87			
			Omitted letter tests					
12	3	0	125–130	1	1	1st	16	0
13	3	0	120–124	4	4	2nd	3	0
14	10	1	115–119	3	8	3rd	0	0
15	2	5	110–114	8	15	4th	15	47
16	3	14	105–109	4	9	P. G.	0	1
17	7	19	100–104	5	6		34	48
18	6	5	95–99	5	3			
19	0	3	90–94	4	2			
20	0	1	85–89	0	0			
	34	48	80–84	0	0			
			75–79	0	0			
				34	48			

of certain city and county schools. A second group was composed of students selected from 134 enrolled in two undergraduate psychology classes at the Johns Hopkins University. In college stand-

ing they ranged from freshmen to graduate students; but two were women. A third group consisted of 28 girls from a first year high school class.

B. THE TEST FORMS AND THEIR USE

1. The Otis Higher Examination, Form A

This test was given under the conditions imposed by the author's Manual to reactors employed in the time-limit vs. work-limit experiment to form two groups approximately equal in mental ability as measured by this standard test.

2. The Pattern Completion Tests

Four requirements seemed desirable in a test for an investigation of work-limit vs. time-limit performance: it should be (1) simple enough to ensure ease of performance, though difficult enough to make the task seem worth while; (2) unusual enough to attract the attention and arouse the interest of reactors; (3) relatively free from associations which might tend to increase individual variations; and (4) applicable to subjects of different ages and different educational qualifications. Since a dot-pattern completion test form seemed to fulfill these requirements, such a test was devised.

The test forms were prepared as follows. Twenty-five open circles arranged in a square constituted the unit for the dot patterns. Four units—A, B, C, and D—formed a basic key row upon which were constructed all the pattern key rows. In each unit one circle was blackened to form a dot. Around these fixed dots—the basic dots—the patterns were formed. Blackening one additional circle in each unit gave a two-dot pattern key row; and blackening two additional circles made a three-dot pattern key row. Two key pattern rows of two dots, Form 1 and Form 2, were made; two key pattern rows of three dots, Form 3 and Form 4. These forms are illustrated in Appendix I. It was arbitrarily assumed that in each key row, whether of two-dot or of three-dot patterns, patterns A and B, owing to the location of their basic fixed dots, would be easier than patterns C and D. Since the test sheet was designed for use with any of the pattern key rows, each of its units was a

duplicate of one of the units of the basic key row—A, B, C, or D—and had consequently one blackened circle. The reactor completed the pattern demanded by the pattern key row at the top by blackening one or two additional circles according to the form used. Each sheet was composed of 120 units, arranged in rows of ten units each. In the 120 units, A, B, C, and D came in chance order. From these test sheets were made the test booklets submitted to the subject.

Each test booklet consisted of four sheets: (1) a sheet with a two-dot pattern key row at the top; (2) one with a three-dot pattern key row at the top; (3) one without a pattern key row; (4) a sheet of directions, so placed that it faced the subject when the booklet lay reversed before him. The purpose of the first sheet, the practice sheet, was to acquaint the reactor with the type of work required. On this sheet the reactor blackened one circle in each unit to make its pattern correspond with the pattern in the pattern key row. The second sheet, the learning sheet, constituted the real learning task. On this sheet the subject blackened two circles in each unit. The third sheet, the recall sheet, recorded the results of the learning. Since here was no pattern key row, the subject added from memory the two dots necessary to make the patterns of the sheet immediately preceding. In one booklet—the 1-4 Booklet—the two-dot pattern Form 1 was combined with the three-dot pattern Form 4. In the other—the 2-3 Booklet—the two-dot pattern Form 2 was combined with the three-dot pattern Form 3. Such grouping was thought advisable since it brought the more dissimilar patterns together. The 1-4 Booklet was kept strictly for the time-limit period; the 2-3 Booklet, for the work-limit period. A third pattern completion test booklet corresponding to the 1-4 and the 2-3 Booklets was provided later for the purpose of investigating the pattern completion tests. This booklet—the 5-6 Booklet—had a new two-dot pattern key row, Form 5, and a new three-dot pattern key row, Form 6. The patterns of both rows, however, were again founded upon the dots of the original basic key row with its four single-dot units, A, B, C, and D. More accurate understanding of the test booklets may be obtained by examining the sample test forms and direction sheet in Appendix I.

3. The Omitted Letter Tests

When comparison of results from the Pattern Completion Tests with results obtained under similar conditions, but with a different type of test seemed desirable, the Dunlap Omitted Letter Tests were used as a second test form. The Omitted Letter Tests demand the crossing out in a given word of a definite letter present in the given word but missing from a jumbled-letter group at the right of the word. They, therefore, require for their accomplishment processes utilized in cancellation tests. As in the Pattern Completion Tests, one form—that beginning with the word Heritage—was reserved for the group time-limit period; another form—that beginning with the word Farthing—was reserved for the individual work-limit period. A third form—that beginning with the word Thousand—was used in investigating the forms themselves. See sample forms in Appendix II.

C. METHOD OF GIVING THE TESTS

1. The Pattern Completion Tests

(*a*) *The Group Time-Limit Tests.* That the group time-limit test might be similar in imposed working conditions to an ordinary school examination, this test was given unannounced, to an entire class, during a regular class period by their regular class teacher. Owing to the newness of the task, a preliminary explanation was believed necessary. Therefore, on a cardboard chart, was presented, in size large enough to be plainly visible to the entire class: (1) a key pattern row similar in design but different in actual pattern from that of any test form; and (2) below this key pattern row, a row of several units each with one circle blackened. While this chart, thus exactly comparable to the pattern key row and the first row of the test sheet, was held before the class, the following explanation was given: *Here is a row of four squares made of little rings. Two of the rings in each square are black. We shall call this row the key row.* The row was indicated. *Look at the squares in the next row. Only one little ring in each square is black. I am going to blacken another ring in the first square so that it will look like a square in the top row.* The appropriate circle was blackened

with a quick circular motion. *I am not bothering to do this perfectly—just enough to show that I have blackened it. Which square in the top row does it now look like?* The correct unit in the key row was pointed out. *Now I am going to do the same with the second square in this row.* The appropriate circle was again blackened. *Which square in the key row does this square look like?* The correct square was again indicated. *Now I am going to do the same with each square in this row. Which ring shall I blacken in the third square?* The entire row was completed, each appropriate circle being blackened in turn, after the correct response. *Now I am going to give you papers on which you will find rows of squares like these. You will find directions on these papers. I shall read the directions as you read them. When the papers are given to you, be sure not to turn them over until you are told to do so.*

After the 1–4 Booklets had been distributed, direction side up, the experimenter read the directions aloud as the pupils read, pausing long enough after the first sentence to permit the recording of name and class. When the directions had been read, the demonstration chart was removed. Special attention was called to the method of blackening the circle: (1) by being careful to make a mere location dot in the preliminary explanation; (2) by giving particular emphasis to the sentence describing such blackening on the direction sheet. At the signals *Ready*! *Turn!* the pupils turned the booklets so the first sheet was uppermost. At *Go*! they began. A three-minute period was allowed on this practice sheet. When time was up for this sheet, the pupils were instructed to fold it back under the direction sheet so that the second sheet came uppermost. They were told, *Look at the key row at the top of the page. You will find three black rings instead of two in each square. In the squares below you are to blacken two rings in each square to make it look like a square in the key row. Begin at the first square in the first row and take each row in order as you did in the last exercise. Be sure to blacken two rings in each square.* A time-limit of six minutes was allowed on this learning sheet. When time was up, the pupils folded back this second sheet, as they had folded the first. They were told, *This time you have no key row. These squares are the same as you had on the last page. You are to try to recall the key*

squares and to blacken the two rings that will make the squares look like the squares in the key row in the last test. Three minutes were allowed and booklets immediately collected.

(*b*) *The Individual Work-Limit Tests.* The individual test was given to one individual at a time. If two reactors worked at the same time, they were seated back to back on opposite sides of a fairly large room and started at widely different times. In this period the demonstration chart was not used. Instead, the pupil read the directions carefully, recorded name and class, then turned the booklet over so that the practice sheet was uppermost. The first unit of the sheet was pointed to by the experimenter, and the pupil was asked to find the unit with the same blackened ring in the pattern key row. This done, the pupil was asked to indicate on the sheet that circle which must be blackened to make the pattern. When the subject clearly understood just what she must do, she was warned to make the mere location dot necessary, told to go at her own speed, but to finish the sheet. She was asked to say *Through*! when the first sheet was completed. The stop-watch, started at the word *Go*! of the experimenter and stopped at the word *Through*! of the subject, gave the time record of the first sheet. When the first sheet had been finished, it was folded back, as in the group test. The pupil was asked to notice the key pattern row of the second sheet and to state how many circles must be blackened in each unit of that sheet. When the pupil understood, she was told to finish this sheet at her own speed, and to report *Through*! as soon as she had finished. The time required was again recorded. The completed second sheet was folded under and the third sheet brought uppermost. The absence of a key row was pointed out and the pupil was directed as in the group test. She was told to complete this sheet also and report *Through*! Time was recorded for Sheet III as before.

The individual test afforded opportunity for close scrutiny of the individual at work. The following factors in the total performance could be noted: the body position; the general muscular movements; the number and kind of movements made by the writing hand; the regularity or irregularity of the work rhythm; the emotional attitude toward the entire task and toward the recall sheet.

The conditions under which the individual worked during the individual tests were far from those held ideal for psychological testing. Certain unavoidable disadvantages must be noted here. The room for the individual tests was situated between an ordinary class-room and a laboratory, both of which were in almost continuous use for school purposes. During work, possible distractions occurred in frequent ringing of hall gongs, raps upon doors, the entrance and exit of janitors or pupils with school notices, and necessary conversation between these and the experimenter. To keep conditions similar for each reactor, like distracting noises were purposely introduced in the few cases where the time of the test assured more ideal conditions. In but few cases was any direct evidence of attention paid to the distracting agent; most subjects went steadily on, and reported at the end of the test that the distraction either had not been observed, or, if observed, had not been annoying.

In both group time-limit test and individual work-limit test, subjects were asked to answer on their test booklets the following questions: (1) Did the test hurt your eyes? (2) Did it tire your hand or arm? (3) Did you like or dislike the test, or were you indifferent? (4) Did you notice any interference from the preceding test? Question 4 was asked in the second test period after Group G had taken Booklet 1–4; and Group I, Booklet 2–3.

2. The Omitted Letter Tests

Sheets used in both time-limit and work-limit periods gave the following directions: "In the two columns of words (the first and the third columns) given below, you are to cross out in each word the letter that is missing from the letter group at the right of the word. The examples are correctly marked.

PLAȣTIC ATICPL SPLENDIƀ NPDLSEI

If there are two or more letters alike, as in SPLENDID, either letter may be crossed out. Begin with the first word in the left hand column and complete that column before taking up the next one."

In the group time-limit period the Heritage form was given to an

entire class during a class period. A time limit of four and a half minutes was imposed. The individual work-limit tests were given in the same room, under the same conditions, as the corresponding Pattern Completion Tests. The reactor began the Farthing sheet at the experimenter's *Go!*, finished the two columns, working at her own speed, and reported *Through!* A stop-watch record of the amount of time from *Go!* to *Through!* gave the time of the work-limit period.

V. Results

A. The Pattern Completion Test-Forms by Time-Limit and by Work-Limit Method

Actual performance on the Pattern Completion Booklets may now be considered by statistical analysis of average scores of the two groups for the two methods, errors, and coefficients of correlation.

1. Scores

Inasmuch as the two testing periods markedly differed in working conditions—one, the group time-limit period, demanding achievement against time; and the other, the individual work-limit period, permitting completion of the task at the rate set by the subject—three factors seemed important in evaluating the individual scores. These factors are quantity of work performed, accuracy of work performed, and time involved. The scores, therefore, for both periods are expressed as efficiency scores, i.e. as the rate of correct work accomplished per minute. In the Pattern Completion Tests, consequently, the scores represent the average number of units correctly filled out per minute. Thereby due credit is given both the quick, careless worker and the slow, cautious plodder. Results are presented in Tables II and III and in Figures 1 to 8.

Efficient accomplishment is shown by the average number of units correctly filled out per minute. Individual differences within a group in either period may be noted in range and standard deviation; variability, in the Pearson coefficient of variation (II), See Figures 1–8.

TABLE II

Summary of means. Pattern completion tests. High school groups. G, time-limit first. I, work-limit first

Score is average number of units correctly filled per minute

SHEET	MEAN	PEM	SD	PEARSON COEFFICIENT VARIATION	RANGE
Group G. Form 1–4—Time-limit					
I	12.778	.258	3.441	26.92	5.00–22.00
II	11.395	.193	2.584	22.67	2.83–19.83
III	13.666	.495	6.614	48.39	0.00–30.67
Total booklet...	12.185	.239	3.200	26.26	2.66–20.00
Group G. Form 2–3—Work-limit					
I	22.210	.368	4.906	22.08	7.98–35.47
II	15.716	.242	3.225	20.52	7.43–23.15
III	21.913	.386	5.153	23.51	3.74–33.64
Total booklet...	19.864	.294	3.924	19.75	7.33–30.67
Group I. Form 2–3—Work-limit					
I	17.736	.362	5.012	28.25	8.52–31.30
II	14.126	.252	3.480	24.63	7.39–29.58
III	19.046	.477	6.601	34.65	1.29–35.62
Total booklet...	16.862	.316	4.382	25.98	6.69–29.74
Group I. Form 1–4—Time-limit					
I	20.058	.338	4.677	23.31	10.00–35.00
II	16.494	.343	4.747	28.78	8.33–26.67
III	22.770	.603	8.340	36.62	1.00–37.00
Total booklet...	18.380	.321	4.450	24.21	8.25–25.83

(*a*) *The Practice Sheet.* For Group G the efficient accomplishment is much higher with work-limit method; for Group I, with time-limit method, although the difference between the scores for the two methods is small. In Group G the range is decidedly

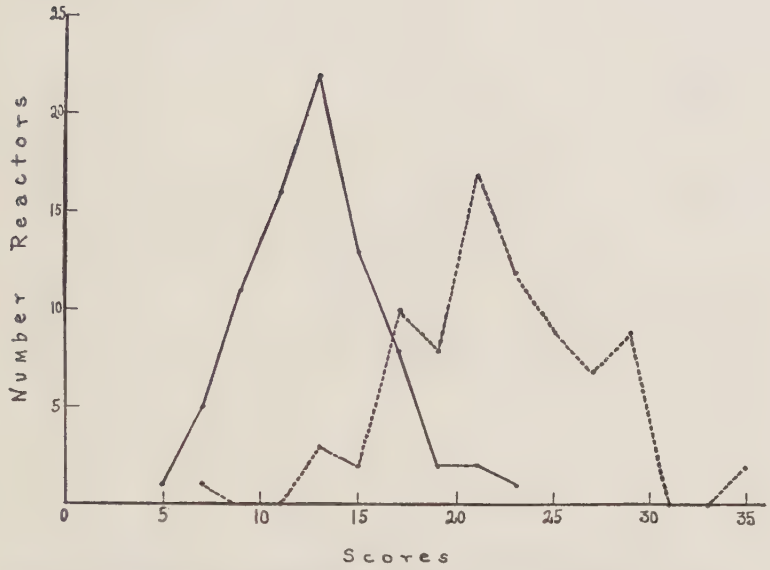

FIG. 1. COMPARISON OF THE SCORES OF GROUP G IN THE GROUP TIME-LIMIT TEST AND THE INDIVIDUAL WORK-LIMIT TEST OF PATTERN COMPLETION TESTS I

Time-limit form ————; work-limit form ----------

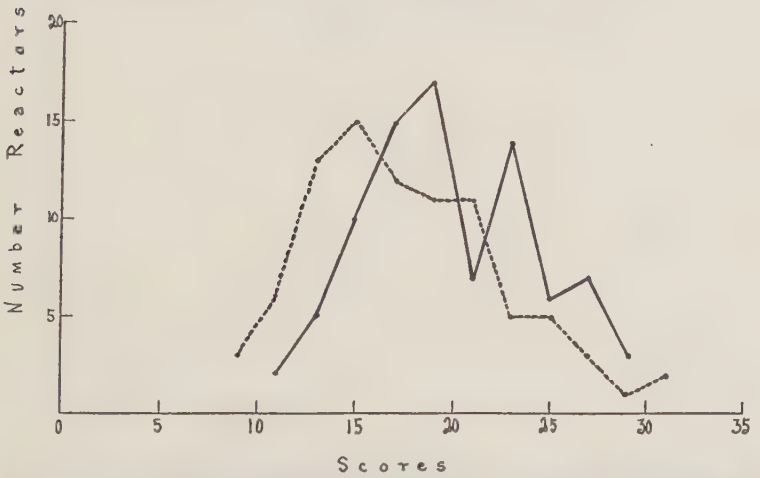

FIG. 2. COMPARISON OF THE SCORES OF GROUP I IN THE GROUP TIME-LIMIT TEST AND THE INDIVIDUAL WORK-LIMIT TEST OF PATTERN COMPLETION TESTS I

Time-limit form ————; work-limit form ----------

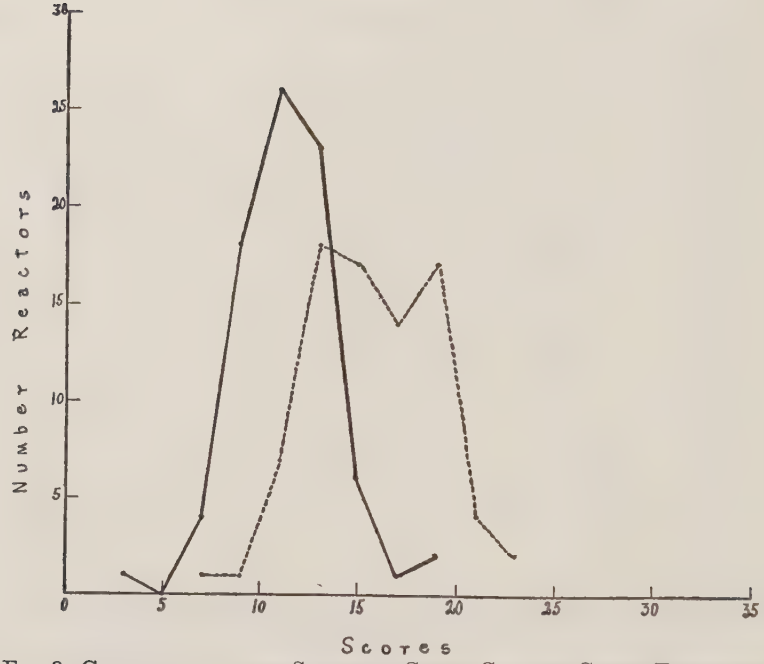

FIG. 3. COMPARISON OF THE SCORES OF GROUP G IN THE GROUP TIME-LIMIT TEST AND THE INDIVIDUAL WORK-LIMIT TEST OF PATTERN COMPLETION TESTS II

Time-limit form ————; work-limit form - - - - - - - -

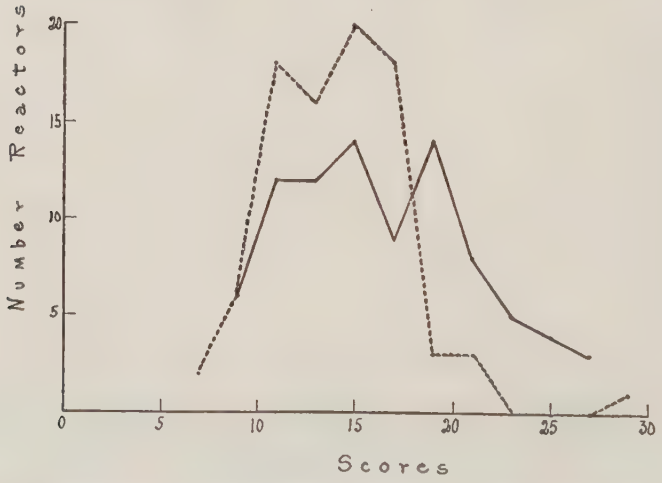

FIG. 4. COMPARISON OF THE SCORES OF GROUP I IN THE GROUP TIME-LIMIT TEST AND THE INDIVIDUAL WORK-LIMIT TEST OF PATTERN COMPLETION TESTS II

Time-limit form ————; work-limit form - - - - - - - -

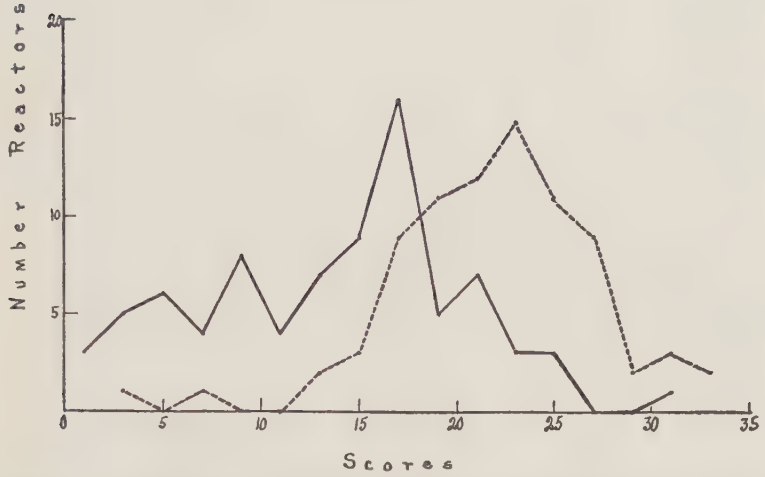

FIG. 5. COMPARISON OF THE SCORES OF GROUP G IN THE GROUP TIME-LIMIT TEST AND THE INDIVIDUAL WORK-LIMIT TEST OF PATTERN COMPLETION TESTS III—RECALL

Time-limit form ————; work-limit form ----------

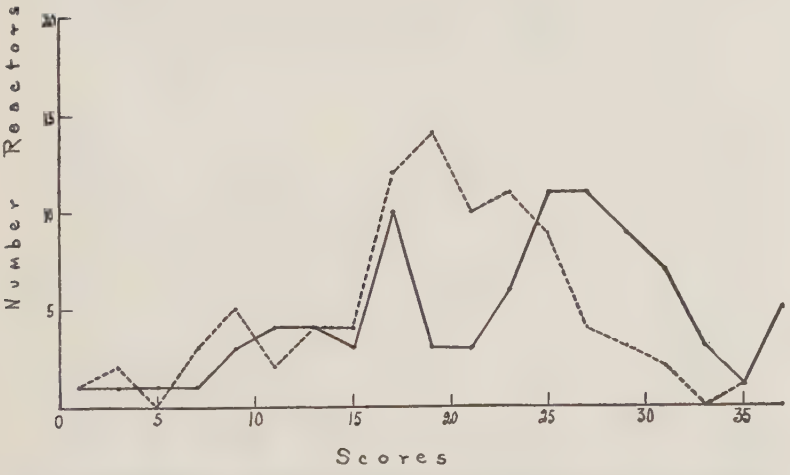

FIG. 6. COMPARISON OF THE SCORES OF GROUP I IN THE GROUP TIME-LIMIT TEST AND THE INDIVIDUAL WORK-LIMIT TEST OF PATTERN COMPLETION TESTS III—RECALL

Time-limit form ————; work-limit form ----------

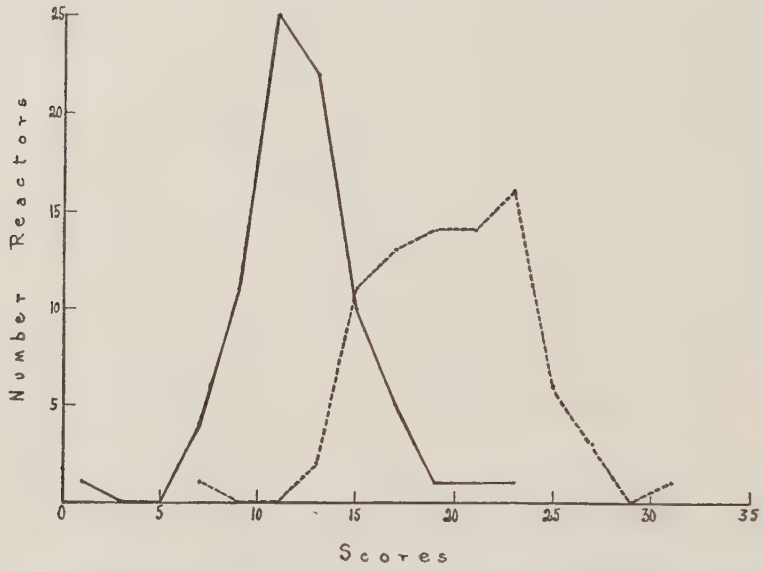

FIG. 7. COMPARISON OF TOTAL SCORES OF GROUP G IN THE GROUP TIME-LIMIT TESTS AND THE INDIVIDUAL WORK-LIMIT TESTS OF THE PATTERN COMPLETION TESTS

Time-limit form ————; work-limit form ---------

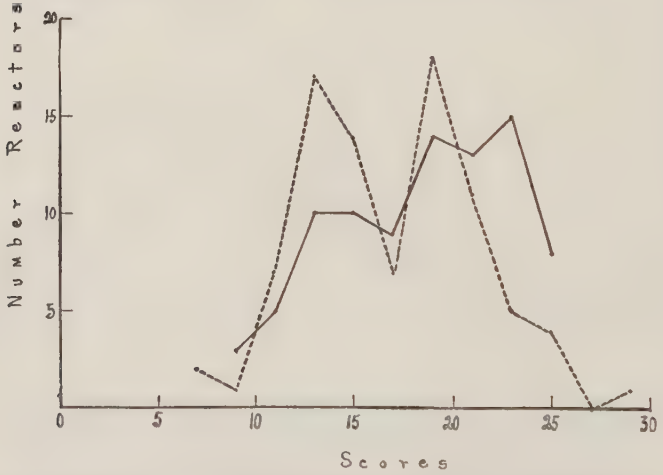

FIG. 8. COMPARISON OF TOTAL SCORES OF GROUP I IN THE GROUP TIME-LIMIT TESTS AND THE INDIVIDUAL WORK-LIMIT TESTS OF THE PATTERN COMPLETION TESTS

Time-limit form ————; work-limit form ---------.

greater for the work-limit; in I, slightly greater for the time-limit. The greater variability for G is found under time-limit method; for I, under work-limit.

(*b*) *The Learning Sheet.* The fact that the efficient accomplishment of both groups is higher in the second test period suggests the influence of practice. The greater range of scores is found for both groups in the first test period; the larger coefficient of variation in the time-limit period, the first period for G but the second for I.

(*c*) *The Recall Sheet.* The first recall test came as a surprise. In the second test period subjects were prepared for it. The surprise of this demanded recall came, however, in different tests in the two groups. In G the surprise sheet was Sheet III of Booklet 1–4; in I, Sheet III of Booklet 2–3. The demand in Booklet 2–3 thus came after completion of 120 units on Sheet II; in Booklet 1–4, after that amount of work permitted by the individual's ability and the time limit. In the latter case varying amounts of practice occurred. For G marked difference exists between the resulting scores of the two periods, those of the work-limit period being much the higher. For I the difference is less, with scores of the time-limit higher. Thus recall scores, too, suggest that amount of practice is influential. The time-limit method produces the greater individual variation in both groups.

(*d*) *Total Performance.* Consideration of total performance indicates the second test period produces the higher average score or efficient accomplishment, regardless of method. Scores made under different time conditions differ less in that group where the individual tests with work-limit came in the first period. The similarity of ranges for both groups when time-limit and work-limit scores are contrasted is interesting; in both groups work-limit method gives the greater range. The total performance shows greater variability between the two methods in that group first tested with a time-limit.

(*e*) *Scores in Units Completed and Time Consumed.* If, instead of efficiency scores, actual scores in number of units completed during a given time and in minutes consumed for a given amount of work are compared, the effect of practice is more apparent. The means given in Table III show that the gain derived by Group

TABLE III

SHEET	MEAN	PEM	SD	COEFFICIENT VARIATION
Time-limit—Form 1–4 (Score is number of patterns correctly completed)				
Group G. First test period				
I	38.055	.744	10.090	26.51
II	67.993	1.166	15.565	22.88
III	41.049	1.511	20.164	49.12
Total booklet...	147.531	2.859	38.153	25.86
Group I. Second test period				
I	59.942	1.027	14.215	23.71
II	94.310	1.572	21.750	23.06
III	68.563	1.821	25.096	36.60
Total booklet...	221.264	3.896	53.920	24.36
Work-limit—form 2–3 (Score is minutes consumed in completing task)				
Group G. Second test period				
I	5.123	.109	1.460	28.49
II	7.049	.101	1.506	21.36
III	4.876	.082	1.104	22.64
Total booklet...	18.382	.269	3.592	19.54
Group I. First test period				
I	6.528	.135	1.874	28.70
II	8.149	.147	2.037	24.99
III	5.574	.121	1.679	30.12
Total booklet...	21.781	.347	4.806	22.06

G from a preceding period is indicated by the lowered time record; that derived by Group I, in increased scores.

2. Errors

Which period—time-limit or work-limit—encourages production of errors? The percent of error in the entire accomplishment for each sheet of the two booklets and for each individual in the two

TABLE IV

Tabulation of errors

T, time-limit method; W, work-limit method

NUMBER OF REACTORS SCORING	GROUP G			GROUP I		
	Sheet I	Sheet II	Sheet III	Sheet I	Sheet II	Sheet III
No errors in either period, T or W.	9	8	9	11	9	13
Same per cent of error	0	1	0	0	2	0
Greater per cent of error on T booklet	61	45	49	57	44	38
Greater per cent of error on W booklet	11	27	23	19	32	36

Summary

	GROUP G	GROUP I
Greater per cent in T on three sheets	22	19
Greater per cent in W on three sheets	0	5
Greater per cent in T on two sheets, no error or same on one	10	4
Greater per cent in W on two sheets, no error or same on one	3	5
Greater per cent in T on two sheets, in W on one.	24	26
Greater per cent in W on two sheets, in T on one.	12	12
Greater per cent in T on one sheet, same or none in two	3	2
Greater per cent in W on one sheet, same or none in two	1	4
Inconsistent on different sheets	6	8
No errors in either	0	2

groups was calculated. Errors included units omitted, units ambiguously completed, and units incorrectly completed. Results are shown in Table IV and Table V.

TABLE V

Average per cent of error

	GROUP G		GROUP I	
	T	W	T	W
Sheet I	8.38	2.59	5.39	2.25
Sheet II	5.49	4.36	4.49	3.15
Sheet III	21.02	5.97	10.50	10.33

TABLE VI

Coefficients of correlation

SHEETS	GROUP G		GROUP I	
	Form 1–4— Time-limit	Form 2–3— Work-limit	Form 1–4— Time-limit	Form 2–3— Work-limit
Coefficients of correlation between scores on different sheets of test booklets with same method of administration; between scores made under the varying conditions and Otis Intelligence Quotients; between scores for different booklets with different methods				
	r	r	r	r
I and II	.5479 ±.054	.6280 ±.046	.6180 ±.046	.7460 ±.033
II and III	.6280 ±.046	.7750 ±.031	.9080 ±.013	.7750 ±.030
I and III	.2403 ±.073	.5075 ±.058	.5277 ±.054	.6081 ±.047
Coefficients of correlation between scores made under the varying conditions and Otis Intelligence Quotients				
I	.1256 ±.077	.2195 ±.074	.3439 ±.066	.5277 ±.054
II	.1151 ±.077	.1569 ±.076	.4261 ±.061	.4465 ±.060
III	.3025 ±.071	.0942 ±.077	.3439 ±.066	.3025 ±.068
Entire performance	.2507 ±.073	.2299 ±.074	.4261 ±.061	.4363 ±.061
Coefficients of correlation between scores for different booklets with different methods				
I	.5176 ±.050		.4363 ±.061	
II	.5580 ±.054		.7750 ±.030	
III	.4056 ±.065		.6873 ±.039	
Entire performance	.6379 ±.046		.7265 ±.035	

3. Correlations

In the Pattern Completion Tests correlations were found: between efficiency scores from Sheets I and II, Sheets II and III, and Sheets I and III of each booklet; between efficiency scores from each of the three sheets and the total of the T 1–4 Booklet as compared with those from each of the three sheets and the total of the W 2–3 Booklet; between efficiency scores from the three sheets and the total of each test booklet and the Otis Intelligence Quotients. These correlations, found by the method of rank-differences (II), since information was desired concerning the existence rather than the actual extent of relationship, are shown in Table VI.

Lest differences in age, school standing, and mental ability play an unrecognized part in the correlations given in Table VI, two

TABLE VII

Correlations in small matched groups

	GROUP G	GROUP I
	r	*r*
1–4 and 2–3	.6775 ±.10	.7265 ±.08
1–4 and I.Q.	.4872 ±.12	.2922 ±.14
2–3 and I.Q.	.1882 ±.15	.3439 ±.16

groups of 20 each were selected from the larger groups, G and I. Every individual in new G was exactly matched in year of chronological age, in school grade, and in Otis Intelligence Quotient by an individual in new I. For these smaller groups correlations were found by the rank-differences method. See Table VII.

Comparison with similar correlations of the larger groups reveals correlations between the efficiency scores of time-limit 1-4 and work-limit 2-3 Booklets are again high and close to analogous correlations of the larger groups. Correlations between the Otis Intelligence Quotient and 1-4 scores for Group I fall; but for Group G, rise. Correlations between the Otis Intelligence Quotient and 2–3 scores drop in both groups. The factors of age and school standing appear to be slightly influential upon the relation

between the Intelligence Quotient and scores made under varying methods of testing. The coefficients show that the performance with time-limit method is more closely related to that with work-limit method than it is to the Intelligence Quotient. It does appear that the Intelligence Quotient is a factor in the increase of score from practice obtained under different timing conditions.

TABLE VIII

Distribution of replies made by high school group

Which pattern was easiest? Which hardest?

FORM 1–4						FORM 2–3					
Sheet I			Sheet II			Sheet I			Sheet II		
Pattern	Easy	Hard	Pattern	Easy	Hard	Pattern	Easy	Hard	Pattern	Easy	Hard
A	99	3	A	100	3	A	56	1	A	66	1
B	44	10	B	46	11	B	13	5	B	17	6
C	4	36	C	4	37	C	4	22	C	5	30
D	1	62	D	1	64	D	3	40	D	3	51

	FORM 1–4		FORM 2–3	
Did the test hurt your eyes?	Yes	53	Yes	17
	No	186	No	117
Did the test tire your hand or arm?	Yes	53	Yes	67
	No	103	No	54
How did you feel toward the test?	Like	160	Like	67
	Dislike	6	Dislike	3
	Indifferent	15	Indifferent	6
Did you notice any interference?	Yes	38	Yes	22
	No	13	No	47

4. Attitude of the Individual

The reactors' attitude toward the tests is indicated by the answers given in Table VIII. The data represent all answers given, including those of reactors who failed to complete the test series.

Evidence from required answers and actual performance on the booklets indicates these facts. (1) Patterns A and B are easier; this is also shown by lack of errors and greater frequency of recall. (2) The booklets apparently had no general adverse effect on the eyes of the reactors. Booklet 1–4, although its use was of shorter duration, is given the greater proportional effect. (3) When time consumed and amount of work done on each booklet are contrasted, the excess of tiring effect in W Booklet 2–3 seems rather slight. (4) Although a few reactors disliked the tests, considering them below their ability, the attitude in general was that the test was a game, to be undertaken seriously, but enjoyed. Great interest was manifested by many individuals in their relative ranks; by others in what the experiment might show. (5) Booklet 1–4 had less opportunity than Booklet 2-3 to influence later accomplishment. Discussion of interference with the reactors brought several variations of answer. Some, failing to recognize any difference between the patterns, believed themselves repeating the same test. Others reported no interference, but indicated interference present by tendency to repeat the preceding patterns perfectly. Many could perfectly recall preceding patterns; such recall was reported sometimes of no adverse effect—sometimes, of marked hindrance.

Time-limit method gave little opportunity for study of the individual. Class attitudes, however, presented marked variations. In many a certain tenseness was plainly discernible. Some had difficulty in understanding their task; others derived much entertainment from their performance. In work-limit tests there were quite different circumstances. Close observation of individuals was always possible. For most reactors the individual test was a serious business. Some remained rigidly bent over their sheet until the end; others showed uneasiness by quick, jerky, unnecessary movements such as pushing hair back, tossing head, or even sudden changes in body posture. Often movements of the mouth and face muscles occurred. Earnest attitude was clearly evidenced in completing the pattern. To place a mere location dot was for many plainly impossible; even after warning, these persisted in making a perfect dot, although they knew such dot required longer time and greater energy.

The surprise recall sheet never failed to produce profound effect. Some individuals were momentarily halted and required a short time to pull themselves together; others accepted the surprise as a matter of slight import and went calmly on with Sheet III. Although the group experiment gave less chance to observe individuals, influence of the group tended either to lessen the effect on the individual, or perhaps more accurately, to repress her outward expression of the effect.

TABLE IX

Summary of means. Omitted letter tests. High school groups

Score is number of letters correctly crossed out per minute

TEST	MEAN	PEM	SD	COEFFICIENT VARIATION	RANGE
Group G. Time-limit first					
Time-limit form heritage.....	6.5000	.244	2.117	32.56	2.67–11.11
Work-limit form farthing.....	7.5883	.221	1.911	25.18	4.04–12.99
Group I. Work-limit first					
Work-limit form farthing.....	7.1458	.166	1.707	23.88	3.08–11.63
Time-limit form heritage.....	8.4584	.176	1.813	21.43	6.22–13.78

B. THE OMITTED LETTER TEST-FORMS BY TIME-LIMIT AND WORK-LIMIT METHOD

As in the Pattern Completion Tests, results from the two periods of testing with the Omitted Letter Forms were studied from analysis of average efficiency scores; errors; coefficients of correlation; and finally general attitude of the individual. Scores are again expressed as rate or efficiency scores, i.e. as the number of letters correctly crossed out per minute. Efficiency scores are given in Table IX and in Figures 9 and 10.

1. Scores

The second test in either group has the higher score. The two average Farthing scores are close, although Farthing as a second

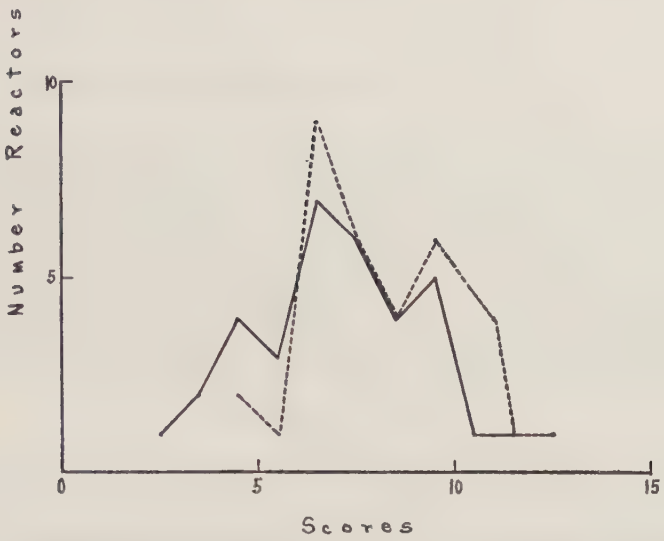

FIG. 9. COMPARISON OF THE SCORES OF GROUP G IN THE GROUP TIME-LIMIT AND THE INDIVIDUAL WORK-LIMIT FORMS OF THE OMITTED LETTER TESTS

Time-limit form ————; work-limit form ----------.

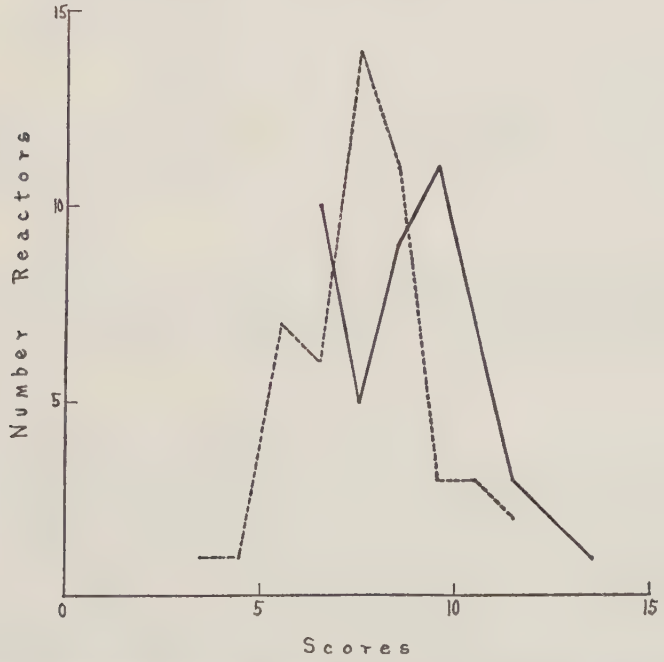

FIG. 10. COMPARISON OF THE SCORES OF GROUP I IN THE GROUP TIME-LIMIT AND THE INDIVIDUAL WORK-LIMIT FORMS OF THE OMITTED LETTER TESTS

Time-limit form ————; work-limit form ----------.

test in Group G has the advantage over Farthing as the first test in Group I. Individual variations may be studied in the range of scores and in the standard deviations. The greater range is presented in both G and I by Farthing, although it is the first test in I and the second in G. Slightly greater difference in range between the two test forms is found in I. When, however, deviations from the mean are studied, G is found to be more variable, and the greatest deviation is located in the time-limit period.

TABLE X

Tabulation of errors

Group G, work-limit first; Group I, time-limit first; T, time-limit method; W, work-limit method

ERRORS	GROUP G	GROUP I
None in either T or W	7	9
None in T, but in W	11	13
None in W, but in T	3	9
In both, per cent the same	1	0
In both, per cent greater in T	7	9
In both, per cent greater in W	5	8
Average per cent of error in T	3.10	2.82
Average per cent of error in W	3.04	3.22

2. Errors

Investigation of the errors made during the two periods reveals facts tabulated in Table X. The errors, which include omitted, uncertain, and incorrect cancellations, are expressed as percents of the total number of cancellations attempted.

3. Coefficients of Correlation

Correlations were found by the method of rank-differences between the efficiency scores for the work-limit and the time-limit methods and between the efficiency scores of each test and the Otis Intelligence Quotients. These correlations are presented in Table XI.

Table XI shows these facts. (1) High correlation exists between test scores for the two procedures in regard to time allowed

in Group G; and significant correlation in Group I. (2) Correlation is higher in both groups between the time-limit scores and the I.Q. than for work-limit scores. (3) The situation in Group I seems especially noteworthy, for here, although the work-limit test was presented as a new experience for the reactor during the first test period, it has less relationship with intelligence as measured by the Otis Test than the following time-limit form has. (4) The correlations throughout for Group G are higher than for Group I.

4. Attitude of the Individual

In the Omitted Letter Tests a report of the individual's attitude toward the two types of work period was obtained. The majority of the subjects favored a work-limit rather than a time-limit period, believing that since the work-limit period allowed the individual to

TABLE XI

Coefficients of correlation in omitted letter tests

CORRELATIONS	GROUP G	GROUP I
	r	*r*
Work-limit and time-limit	.8039 ±.043	.5176 ±.074
Time-limit and I.Q.	.5277 ±.087	.4973 ±.076
Work-limit and I.Q.	.4771 ±.093	.3439 ±.089

proceed at his own rate of speed, it enabled him to accomplish a better piece of work. Some few, however, preferred the time-limit period in that it demanded greater concentration and greater energy. Still others professed equal satisfaction with either period.

C. COMPARISON OF PERFORMANCE IN THE TWO TEST FORMS

Fifty-five students served as reactors in both the Pattern Completion and the Omitted Letter Tests. If the reactor belonged to Group G in one set of tests, she was arbitrarily placed in Group G in the other type. To discover whether performance in the Pattern Completion Tests approximated performance in the corresponding test of the Omitted Letter set, comparison of ranks in the two dissimilar tests was made. These are given in Table XII.

Coefficients of correlation were obtained between the efficiency scores in the two types of tests when given with time-limit, and also when given with work-limit method. These coefficients are shown in Table XIII.

TABLE XII

Comparison of ranks in the two test forms

T, time-limit method; W, work-limit method; G, group test with work-limit; I, individual test with time-limit

	GROUP G	GROUP I
Number with rank higher in T in both test series.	4	3
Number with rank higher in W in both test series.	6	7
Number with rank higher in T in pattern completion; same rank in omitted letter.....	1	0
Number with rank higher in W in pattern completion; same rank in omitted letter.....	1	2
Number with rank higher in T in omitted letter; same rank in pattern completion.....	1	3
Number with rank higher in W in omitted letter; same rank in pattern completion.....	2	1
Number with rank higher in T in pattern completion; higher in W in omitted letter.....	6	7
Number with rank higher in W in pattern completion; higher in T in omitted letter.....	5	6
Totals.....	26	29

TABLE XIII

Correlations between the two test forms

	TIME-LIMIT TESTS	WORK-LIMIT TESTS
	r	*r*
Group G.....	.7847 ±.05	.5176 ±.10
Group I.....	.0314 ±.13	.5277 ±.09

For time-limit tests the coefficient of correlation is much higher for that group first tested under time-limit conditions. For work-limit tests the two groups show approximately the same relations between performance in the two types of tests. In both groups,

therefore, the higher correlations occur between initial performances.

Comparison of correlations between the two types of test forms and the Otis Intelligence Quotient is given in Table XIV.

Interpretation of Data

The statistical analysis of the data indicates two obscuring factors for conclusions regarding the time-limit versus work-limit method of determination of mental abilities. Practice under either method appears to increase the score under the second condition of testing; the two forms of the same type of test do not appear to be of equal difficulty.

TABLE XIV

Coefficients of correlation between the efficiency scores for the two types of tests and the intelligence quotient

TEST AND METHOD	GROUP G	GROUP I
	r	*r*
Time-limit pattern completion and I.Q...	.2507 ±.073	.4261 ±.061
Work-limit pattern completion and I.Q...	.2299 ±.074	.4363 ±.061
Time-limit omitted letter and I.Q.....	.5277 ±.087	.4973 ±.076
Work-limit omitted letter and I.Q.....	.4771 ±.093	.3439 ±.089

Pattern Completion Tests

As a preliminary step in interpreting results of the Pattern Completion Tests, information was sought concerning the relative difficulty between the booklets. These booklets had been used by Miss Agnes Snyder with a large group of fourth-grade children, by group time-limit method. Each child took but one form. The assumption was made that a comparison of the performances of two groups approximately equal in age, school standing, social environment, and mental ability, one of which took one booklet and the other, the other form, would give some insight into the relative difficulty of the two booklets.

For comparison of scores, four mean scores were obtained for each group: the average number of patterns correctly filled in (1)

on the practice sheet during the allotted three minutes; (2) on the learning sheet during the allotted six minutes; (3) on the recall sheet during the allotted three minutes; (4) on the entire booklet within the allotted twelve minutes. The results, given in Table XV, show for each sheet and for total performance higher scores for the 2–3 Booklet. Therefore, the 2–3 Booklet is of less difficulty.

Results from the fourth grade had no complications of practice effects from a similar test. Scores were earned in a first trial. Two questions now presented themselves. (1) Would difference in scores between the booklets persist if the subjects had had a similar preliminary test? (2) Would practice gained by working

TABLE XV

Pattern completion test scores for fourth grade children

Number of patterns correctly filled in allotted time

SHEET	BOOKLET 1–4			BOOKLET 2–3			DIFFERENCE
	Means	PEM	SD	Means	PEM	SD	
I	15.60	0.61	6.48	17.95	0.75	6.45	2.35
II	26.60	1.03	10.80	28.86	1.53	13.04	2.26
III	12.10	0.88	9.26	14.77	1.51	12.85	2.67
Totals...	53.80	2.06	21.68	60.76	3.36	28.60	6.96

on one booklet influence performance in the other? Information was sought as follows. A preliminary 5–6 Booklet was first given a group of 134 university students during a regular lecture hour as a group time-limit test. A three-minute time-limit was allowed on Sheet I; a four-and-a-half minute time-limit on Sheet II—a time purposely shorter than the six-minute allotment with the hope that no reactor would finish; and a three-minute time-limit on Sheet III. The preliminary explanation and directions were those of the group time-limit test. At the end of the test, answers to certain questions were recorded. On the basis of scores earned on the 5–6 Booklet, two equal ability groups—A and B—were formed. A second group test was given a week later; a third

group test, two days after the second test. In the second test period, Group A took Booklet 1–4; Group B, Booklet 2–3. In the third test period, Group A took Booklet 2–3; Group B, Booklet 1–4. Time-limits in each test and each period were the same as

TABLE XVI

Pattern completion test scores for the university groups

Number of patterns correctly completed in allotted time

SHEET	GROUP A			GROUP B		
	Mean	PEM	SD	Mean	PEM	SD
	Form 5–6			Form 5–6		
I	36.87	.91	7.68	40.76	.92	8.94
II	48.75	.99	8.38	48.78	.99	9.70
III	23.12	1.68	14.12	26.68	1.73	16.84
	Form 1–4			Form 2–3		
I	58.44	1.31	11.00	74.94	2.02	19.61
II	60.00	1.40	11.79	65.98	1.67	16.26
III	43.44	2.46	20.67	60.98	2.08	20.18
	Form 2–3			Form 1–4		
I	82.97	2.06	17.30	71.92	1.85	18.08
II	81.72	1.68	14.15	75.18	1.78	17.39
III	77.65	2.58	21.59	71.45	2.12	20.67

Totals

GROUP A				GROUP B			
Form	Mean	PEM	SD	Form	Mean	PEM	SD
5–6	109.37	2.63	22.06	5–6	115.00	2.84	27.78
1–4	160.62	3.96	33.25	2–3	199.88	5.01	48.76
2–3	241.25	5.08	42.62	1–4	217.79	4.49	43.63

in the preliminary booklet. Records present only those students of Group A and Group B still at work when time was called: in Group A, 32 reactors, two of whom were women; in Group B, 43 reactors, all men. Average performance in A or B Group on

each booklet as shown by the mean score on each sheet and total is recorded in Tables XVI and XVII.

After one practice period and after two practice periods the 2–3 scores are higher. They remain so if practice periods are equated by comparing the combined 2–3 scores of A and B with the combined 1–4 scores. Practice effect may be seen by contrasting 1–4 scores in the second period of A with those in the third period of B; also 2–3 scores in the second period of B with those in the third period of A.

The requested answers regarding the general effects of the test booklets gave the following facts supporting the statements of Groups G and I. (1) Assumption that certain patterns were

TABLE XVII

Pattern completion tests. Comparison of scores on booklets 1–4 and 2–3, university groups

Average scores of Group A plus Group B

SHEET	1–4	2–3	DIFFERENCES
I	130.36	157.91	27.55
II	135.18	147.70	12.52
III	114.89	138.63	23.74
Totals.....	378.41	441.13	62.72

easier was warranted. (2) The test booklets have some, but not a general, effect on the eyes of the subjects. (3) The test booklets have some, but not a general, effect in tiring the hand or arm. (4) Attitude toward the test performance is in general favorable, or not adverse. (5) Interference through recall of patterns from a preceding booklet is in general denied.

In summary, results from the fourth grade and the university groups indicate two factors influencing scores of Groups G and I. The 1–4 Booklet employed in time-limit method is slightly more difficult; and practice effect is produced by performance in either booklet. The amount of practice any individual of Group G or I gained was dependent upon her rate of accomplishment in the granted time.

Conclusions for the Pattern Completion Tests

CONCLUSIONS FROM SCORES OF GROUPS G AND I

Variations between the two methods, time-limit and work-limit, as shown by efficiency and by actual scores are partly due to other conditions of the test periods. Consideration of total performance by both groups in both periods seems to warrant the conclusion that in this type of test the amount of practice has more potent influence on performance than the time conditions under which the test is taken; and that a preceding practice period tends to smooth out individual differences evidenced in an initial attack.

CONCLUSIONS FROM ERRORS

For both groups the greater percent of errors occurred in the time-limit performance. The newness of the task and the unexpected demand for recall played their parts in producing errors. In general, however, the conclusion seems reasonable that the time-limit period is more favorable to the production of errors.

CONCLUSIONS FROM CORRELATIONS

The fairly high agreement between the rankings of individuals for the two methods shows that rank in scores earned in the Pattern Completion Booklets is not determined solely by the conditions of time-limit or work-limit. Coefficients of correlation seem to indicate that for comparison of test scores with the Otis Intelligence Quotient there is little difference between scores from time-limit and work-limit methods; the newness of the task seems of greater importance than the method by which the task is accomplished. It seems likely that work rhythm is a personality trait and is in most cases not greatly influenced by imposed work methods. Those individuals who work rapidly in a time-limit period tend to work rapidly in a work-limit period; those who take their time in a work-limit period act similarly in a time-limit period. The experimenter doubts, however, that all idea of work against time can be obliterated even in a work-limit period, since speed as a goal is so thoroughly emphasized in our present world.

In summary, these coefficients of correlation would seem to

justify the general conclusions: that in this type of performance the two working methods are of almost equal value; that the position of the test period is important, since previous experience in this type of performance tends to increase agreement between the two methods; that initial performance by either method seems to measure better the abilities represented by the Otis Intelligence Quotients.

CONCLUSIONS FROM BEHAVIOR OF THE INDIVIDUAL

Observation of conduct during the tests indicates that the individuals tested may be roughly divided into three classes. First are the steady, thorough-going workers who keep right on with the task, no matter what the conditions. These are equally comfortable in group time-limit or individual work-limit tests. Second are workers exhilarated by the consciousness of the group or of the time restriction; their performance is markedly superior in the group time-limit test. Last are reactors who are more at ease in the work-limit test where they feel free to proceed at their own pace without the disquieting influence of the time-limit and rival workers. That wide variations are exceptional rather than general seems to indicate that accomplished work is much less influenced by the conditions under which it is performed than is generally conceded.

THE OMITTED LETTER TESTS

To gain some knowledge of the relative difficulty of the forms used, and of the practice effect of performance, an experiment was carried out with the group of university students that had served as reactors in investigating the Pattern Completion Booklets. Three forms of the test, designated I, II, III, were used. Form I was given as a preliminary test during a regular lecture period. The test was given as a group test with a time allowance of four minutes—a time too short to admit of any reactor's finishing. Information regarding the type of word in which errors more frequently occurred was obtained by having each reactor at the end of the allotted four minutes number his marked words by the following scheme:

3—a word very familiar; very frequently used
2—a word rather familiar; rather frequently used
1—a word unusual; rarely used
0—a word unfamiliar; never used

On the basis of scores earned in this preliminary test two equal ability groups of 21 each—Groups A and B—were formed. Form I was followed a week later by a second group test. In this second

TABLE XVIII

The omitted letter tests. Means of the university groups

Score is total number of letters correctly crossed out

GROUP A				GROUP B			
Form	Mean	PEM	SD	Form	Mean	PEM	SD
I	33.93	1.05	7.14	I	34.07	0.97	6.63
II	33.93	1.30	8.86	III	39.49	1.03	7.00
III	43.64	1.36	9.28	II	40.35	1.35	9.18

Average scores of Group A plus Group B { Form II..... 74.28 / Form III..... 83.13

TABLE XIX

The omitted letter tests. Means of the first year high school group

Score is total number of letters correctly crossed out

FORM	MEAN	PEM	SD
I	29.31	0.65	4.53
II	25.63	0.87	6.09
III	31.09	0.83	5.81

period, Group A took the form of the time-limit period in the time-limit vs. work-limit study, Form II, while Group B took the form used in the work-limit period, Form III. In a third test two days later, these forms were reversed for the two groups. The time-limit in each period was four minutes as in the first preliminary period. Marked words of each form were also evaluated. Mean scores for the two groups are given in Table XVIII.

Comparison of average scores given in Table XVIII shows that Form II is more difficult than Form III. Practice effect is evident if second period scores in either test be compared with the corresponding scores of the third period. Word ratings indicate that error is not determined by the unusualness of a word.

To determine whether results obtained from university men would be similar to those obtained from high school girls, an analogous experiment using as subjects a first-year high school class was tried. Form I was given in the first test period; Form II, in the second; Form III, in the third. Conditions and directions in all three periods were the same as those in the university groups. Twenty-two complete records were obtained. Results were in close agreement with those of the university group A. (See Table XIX.)

The first year high school class and the university groups proved: (1) Form II is more difficult than Form III, and (2) practice effects are present after one trial of this type of test.

CONCLUSIONS FOR THE OMITTED LETTER TESTS

In the Omitted Letter Tests consideration of average score, range of score, and deviation from mean within either group and in both groups would seem to indicate that in this type of test a preceding practice period, unlimited as to time, tends to increase scores in a similar following test. At the same time individual differences and variations so valuable in ranking an individual tend to be lessened and smoothed away. While the tendency of a preceding time-limit period is similar, its shorter length does not admit of so decided an effect. It would seem wiser, therefore, in this type of test, if information is desired regarding an individual's ability as contrasted with that of others in a similar group, to use but one test—a time-limit test. This is fairer to the individual and more enlightening for the investigator.

Results seem to indicate that in this type of test the location of the test period has more effect in producing errors than either the degree of difficulty of the test form or the method by which the test is administered. The proportion of errors is greater in the first test period than in succeeding ones.

Coefficients of correlation seem to warrant the following conclusions: (1) In this type of test fairly close agreement exists between the accomplishments of an individual under time-limit and work-limit conditions when such accomplishment is expressed in efficiency scores equally evaluating accuracy and speed; (2) the Omitted Letter Test has greater prognostic value if given by time-limit as an initial performance.

GENERAL CONCLUSIONS

Analysis of results obtained in the foregoing investigation in which two types of test material were given to two groups equally able according to Otis Intelligence Test scores, seems to warrant the following conclusions:

(1) That on the average there is no significant difference between ratings for the same individual by the time-limit and work-limit methods. In a few exceptional cases performance seems favored by one or the other method.

(2) That practice effects tend to exceed differences that might be due to a change in method of administering the test.

(3) That the work-limit period has slightly greater value than the time-limit period in raising the rank of an individual and in decreasing individual differences.

(4) That ability in the performances studied is more prognostic of ability in other mental tasks such as are offered by intelligence tests if the time-limit method is used in the initial performance of the task.

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APPENDIX I

PATTERN COMPLETION TEST FORMS

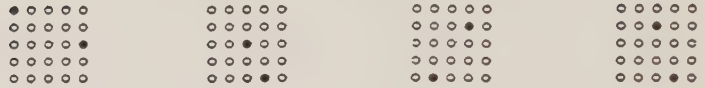
DIRECTION SHEET

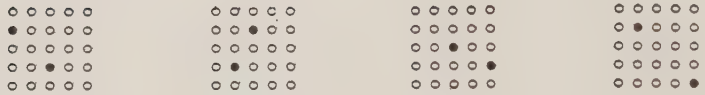
Do not turn your sheet until you are told to turn it

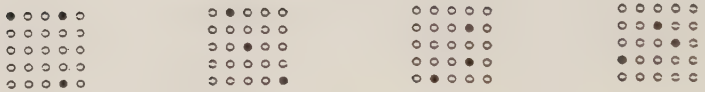
Record at the bottom of the sheet the date, the hour, your name and school year. When you do turn your sheet (not now—wait until told) you will find at the very top a key containing four squares: in each of the four squares two of the little circles are black. Below the key are rows of squares in which just one dot of the pattern is black. Put a dot in the circle that should be black according to one pattern in your key, that is, make a circle black that will complete the patterns given in the key. Just a good black dot is all that is necessary, not a line which may extend over two dots and make your square incorrect. Go across your page from left to right beginning at the first row and taking each row in succession. Do not omit any. Work as quickly and as accurately as you can. If you finish before signal is given to stop, raise your hand.

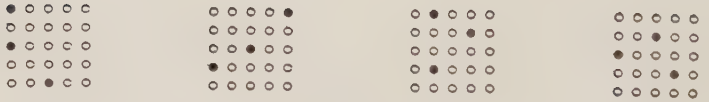
Ready. Turn. Fold your sheet back so that you can work easily. Go!

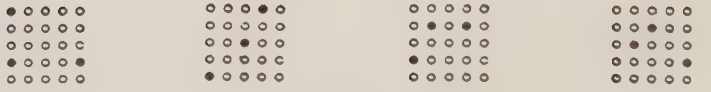
KEY PATTERNS FOR OTHER FORMS OF PATTERN COMPLETION TEST USED WITH SAME WORK-PATTERNS AS GIVEN IN I.

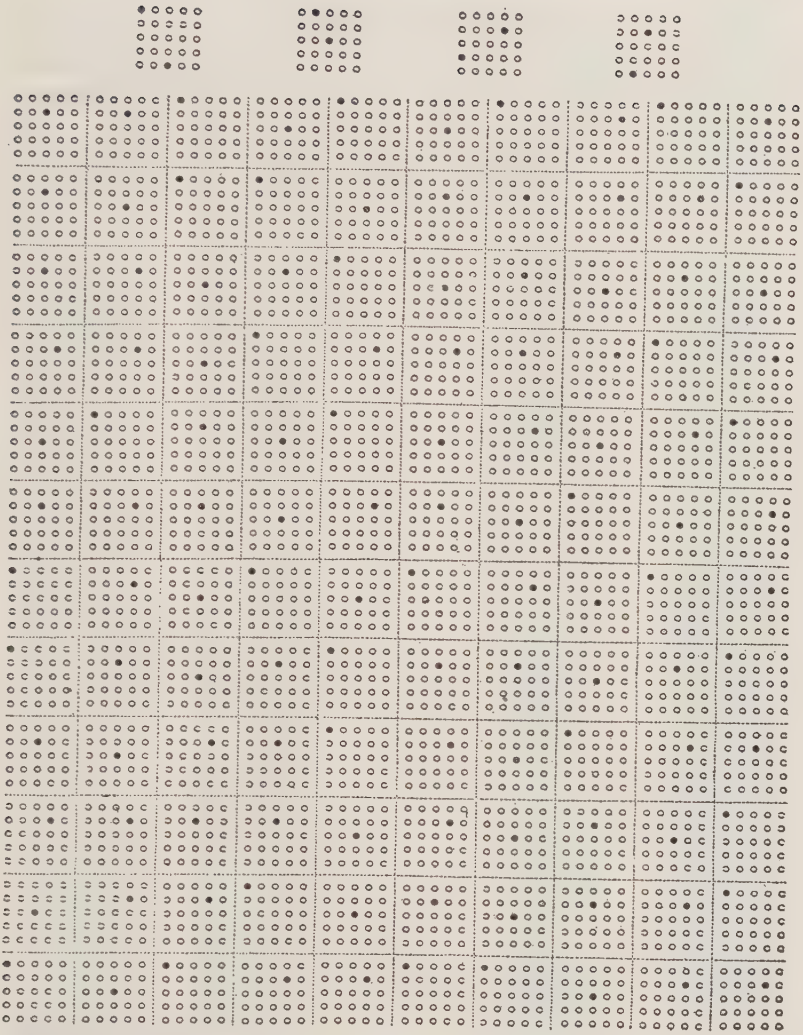
II. 

III. 

IV. 

V. 

VI. 



Pattern Completion Test, E-1, Form 1
Johns Hopkins Series, Psychological Tests.

Appendix II

OMITTED LETTER TEST FORMS

DIRECTION SHEET

In the two columns of words (the first and the third columns) given below, you are to cross out in each word the letter that is missing from the letter group at the right of the word. The examples are correctly marked.

PLAȘTIC ATICPL SPLENDIÐ NPDLSEI

If there are two or more letters alike, as in SPLENDID, either letter may be crossed out. Begin with the first word in the left hand column and complete that column before taking up the next one.

FARTHING	RNFIAGH	MORTGAGE	RMTAOEG
LACERATE	TLEAERC	IGNORANT	IOAGTRN
LANDMARK	RLDAKMN	OCCIDENT	IECTDCN
LOVELORN	RLEOONV	EFFUSION	EUIFNSO
PROLIFIC	IPLFCIO	DISCRETE	DCEIRST
INUNDATE	TIANEDU	BANISTER	BITARSE
CONSTRUE	UCSOETN	PLUMBING	PMIGBUN
SNOWPLOW	OWLNWPO	DISTANCE	TNIEASC
TABULATE	TTUAAEL	CONVINCE	CVNEINC
CHRISTEN	THNSREI	DRESSING	SIGSEND
HIGHLAND	AIDLGNH	FISHWIFE	HIIEWSF
MANEUVER	VARUEME	PAVEMENT	EEATMVN
BOBWHITE	IOEHTBW	DISCLOSE	OIELSSD
HOMICIDE	OECMDHI	PINAFORE	AOIEFRP
DIPLOMAT	MTOPADL	LUSCIOUS	COUISUL
PROCLAIM	ARLOIPC	INDIRECT	INTRDCI
HORSEMAN	MOERAHS	ESTHETIC	HTCETIE
BOUNDARY	OYDURNA	BLUEFISH	FUSBEIL
OVERGROW	VWGEORR	LENGTHEN	TNELGHE
LIFETIME	IETMLEI	INSECURE	CSRIEUN
DWELLING	WGENDLI	HORNPIPE	EPRHNIO
IMPOSTOR	MRSPIOT	CALENDAR	RNLACDA
PATIENCE	AEETCIN	INTERACT	TRTCIAN
IMPOLITE	MEPTIOI	DISCLAIM	MLSIDCI
DUMPLING	UGLMNPI	NORSEMAN	ERANMON
LATITUDE	ETDLIUA	INSULATE	LSTIANE
FLOURISH	OSFUILR	LARKSPUR	RULKPAR
INFANTRY	FRIATNY	DISJOINT	OSNDJIT
AUDITION	OAIIUNT	LUTHERAN	TALHRUN
LEGATION	GOLAENT	POWERFUL	WUPEFOL
GRADUATE	AGDAREU	RUDIMENT	MDRIEUT
STIMULUS	IUSMLSU	CLOISTER	SOECITR

HERITAGE	IAETRGH	HIGHROAD	IDRGAHO
LETHARGY	GLHREYA	INSTANCE	ASCTNNE
FLOUNDER	NOEFUDR	DESPATCH	PTHASCD
GLOBULAR	UOAGBLR	CONTRAST	TAOTNSC
MASTODON	DANOSMT	PLATINUM	TNLMIUP
FORSWEAR	EOWRAFS	SANCTIFY	CIAYTFS
PROBABLE	AOLPBRE	DRUGGIST	RTGUDGI
DECREPIT	CIDRPET	CLASSIFY	AFCSILY
ADAPTIVE	VAPIDET	WOODBINE	NWDIOEB
GRANDEUR	AUGERRD	HOODWINK	NDIOKWO
PROHIBIT	IHBRTIO	POSTPONE	PTOOEPN
HARANGUE	UHGAENR	VOLITION	VIIONTO
HERCULES	HCLESUR	MAGICIAN	NCGAMIA
FEASIBLE	LFSBEEA	CREAMERY	YMECAER
CONTRACT	ATRNCCT	SHEPHERD	HDHERPE
SIXTIETH	EIHIXST	MARKSMAN	SAMKMAN
SURCEASE	AUERSSC	REGISTER	GERITES
CONSTANT	OTTNNCS	MISPLACE	MPAIELS
COINCIDE	CNIOEID	SWINDLER	RIESNLW
DISBURSE	DBRIEUS	ADMONISH	DHNMAOI
HUNTSMAN	HTMUSNA	INFORMAL	NRFAIOM
HERALDRY	HDEYLRR	DELUSION	LDUIENS
HISTORIC	HTRICSI	JUDGMENT	DNGEUTM
RIDICULE	RIIECDL	MISJUDGE	SGMJDEU
IMPRISON	NPOIRSM	INTERVAL	AIVNLRT
DOMICILE	ECMLDIO	CLOTHING	NEILGHO
DERISION	NSRODII	DISPLACE	LSCDAIE
PUGILISM	MLGSPII	ORGANISM	IRNGSOA
HIRELING	GLRNHEI	OVERLAND	LENOAVD
FORESTRY	YSRRFET	SOUVENIR	NOREUIV
HUMANISM	UMNMSHI	OVERHANG	RAVGHEN
ASTERISK	SKRTSEI	UNDERPAY	EPYRDAU

THOUSAND	NUTOSHD	OUTRIGHT	TOHUGIR
LOVELORN	OLEOVRN	PROLIFIC	IPILOCF
SHORTAGE	HORSEAT	FIFTIETH	TIFHEFI
FRACTION	NARCOTI	SIXTIETH	SITHETX
INHERENT	RENHTNI	FOURFOLD	LOUDFRF
PROBABLE	BOPLERB	DESOLATE	OATSELD
OUTSKIRT	TROTSKI	EVENTFUL	LEFTNUV
INDOLENT	LINETON	UNDULATE	UTANDEL
MORALIZE	ZALMORI	FIVEFOLD	FODVIFL
MEDIATED	DEMIADE	CULPABLE	PELCLAB
EASTWARD	SWATDER	SARDONIC	NICODAS
CONJUGAL	GLOACJN	SOLVABLE	LOVEBAS
VOLATILE	TAVLOIL	BRACELET	LARTEBE
FOLKSONG	KONFGOS	CREAMERY	MEREYAR
SKELETON	TELEKON	BEVERAGE	VEBREGA
LAVENDAR	VLEDANR	BOBOLINK	KOLONBI
REPUBLIC	CUPELBI	DOMESTIC	SOTCMID
LUMINOUS	SINUOMU	PORTABLE	LEBATOP
DOMINANT	ONITMDA	NUISANCE	CANISUN
MEMBRANE	BEMENAR	KEEPSAKE	PEKEKEA
CREATURE	TUEARCE	PHARISEE	HESPEIA
ESTHETIC	SETCETI	CARDINAL	DICRANL
SURVIVOR	RUVISOV	ACOUSTIC	CASUCOT
SCORPION	RIOPSON	MONARCHY	CHYMONA
SENTENCE	ENTECES	DELEGATE	TELEGAD
LANDLORD	DANLODR	TENDENCY	CENTDEY
EMPHATIC	HAMCIEP	BLUEFISH	SHEBIFU
DOMICILE	MODILEI	PLUMBING	BIGNPUM
STRINGED	GDRNISE	VERTICAL	RITVCAL
TEMPORAL	ROAPTEL	TRANQUIL	LANQURI
FRICTION	TRINOCF	COLOSSAL	LOSALOS
FLYSPECK	PYKSCLE	YOUTHFUL	LUYHOFU

VITA

The writer was born in Baltimore, Maryland, on February 15, 1889. Her education, elementary and secondary, was received in the public schools of Baltimore. She was graduated from Goucher College with the A.B. degree in 1910. From September, 1910, until June, 1927, she was teacher of academic subjects in the Western High School, Baltimore. She was enrolled as a graduate student in the Psychology Department of Johns Hopkins University from September, 1920 to June, 1928. She was graduated from Johns Hopkins University with the Ph.D. degree in 1928. She is a member of Phi Beta Kappa and Sigma Xi.